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The bolster technique utilising small intestinal submucosa wound matrix: A novel approach to wound treatment

Francis J. Collini[1] | **Samantha C. Stevenson**[2] | **Jason P. Hodde**[2]

[1]Renaissance Center for Plastic Surgery, Shavertown, Pennsylvania

[2]Cook Biotech Incorporated, West Lafayette, Indiana

Correspondence
Samantha C. Stevenson, Cook Biotech Incorporated, 1425 Innovation Place West Lafayette, IN 47906.
Email: sstevenson@cookbiotech.com

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Cook Biotech Incorporated

Abstract

Managing acute wounds with soft tissue loss can be very challenging for both patients and physicians. Successful wound healing depends on several factors including exudate control, prevention of infection, and moisture balance. In this case series, we describe a novel combination treatment method utilising small intestinal submucosa wound matrix (SISWM) with the bolster technique as a way of assisting the integration of collagen-based wound treatment products into the base of complex wounds with the intent of restoring a dysfunctional extracellular matrix. In case 1, a 44-year-old female presented with an acute wound resulting from a spider bite to the posterior aspect of the right knee. In case 2, a 12-year-old male sustained multiple injuries to his right foot from an all-terrain vehicle accident. In case 3, an 80-year-old female on anticoagulants sustained an avulsion injury to her left lower leg. In case 4, a 41-year-old female sustained a severe complex avulsion injury to the dorsal left forearm sustained from a dog bite. All patients were successfully treated with SISWM and the bolster technique, and their wounds healed completely within 6 weeks. The bolster technique, when combined with an SISWM, is a novel method designed to enable the SISWM to impart its wound healing properties to these complex traumatic wounds. This case series presents treating clinicians with a different treatment methodology to assist the patient in achieving a successful outcome.

KEYWORDS

complex acute wounds, extracellular matrix, skin grafting, small intestinal submucosa, wound healing

1 | INTRODUCTION

Acute wounds are a common and potentially complex problem for both physicians and patients. Approximately 11 million acute wounds occur in the United States each year.[1-3] Acute wounds can be either superficial, involving the epidermis and superficial dermis, or full-thickness, in which the subcutaneous layer is also compromised.[4] Soft tissue loss because of infection or trauma can be especially challenging and is commonly treated in a staged fashion. Ultimately, the goals for wound care are to achieve rapid and functional wound closure, minimise the risk of infection, and limit scar formation to achieve an aesthetically pleasing outcome.[5]

Standard treatment for wounds that are characterised by significant soft tissue loss includes debridement to remove devitalized tissue followed by application of an appropriate dressing to control infection and to maintain a moist environment conducive to wound healing. Once the wound bed

contains adequate granulation tissue, secondary closure can be performed, typically utilising a skin graft or a flap. To promote wound healing, wound matrices derived from natural collagen are becoming more widely utilised.

Small intestinal submucosa wound matrix (SISWM) (Oasis Ultra Tri-Layer Matrix, Smith & Nephew, Fort Worth, Texas) is a collagen-based extracellular matrix material (ECM) derived from porcine small intestinal submucosa that consists of multiple collagen types and ECM components.[6] SISWM provides a complete scaffold that supports new blood vessel growth as well as the deposition and maturation of ECM components involved in tissue repair and remodelling.[7] The body gradually incorporates the small intestinal submucosa into the surrounding tissue, eliminating the need for its removal and resulting in the formation of a granulation tissue bed that can be left to heal by secondary intention or can be used to support a skin graft or myocutaneous flap.

The method by which SISWM is applied to a wound is important because it needs to impart the critical wound healing components that will support tissue reconstruction and angiogenesis,[8,9] attack and disrupt biofilms, and restore normal anatomic integrity to the patient's disrupted dermis and epidermis.[10] The bolster technique described herein addresses these issues directly.

Key Messages

- This article is a case series describing four patients with complex acute wounds who have received a novel treatment therapy, "bolster technique"
- The use of bolster technique combined with a small intestinal submucosa wound matrix (SISWM) can facilitate healing in complex traumatic wounds
- SISWM is a collagen-based extracellular matrix material (ECM) that is derived from porcine small intestinal submucosa. It provides a complete scaffold that supports angiogenesis as well as the deposition and maturation of ECM components necessary for tissue repair and healing
- In our practice, combining SISWM with intermittently instilled antibiotic solution and a bolster dressing has shown promising results in wound healing

2 | BOLSTER TECHNIQUE

The bolster technique is used to shorten the bridge between injury and wound re-epithelialization and incorporates the use of SISWM; mupirocin calcium; Adaptic (KCI Licensing, Inc., San Antonio, TX); cotton ball(s) moistened with mineral oil; a paediatric feeding tube; and a suture tie placed over the bolster to maintain adherence of the SISWM to the base of an open wound (Figure 1). This technique enables postoperative intermittent instillation of a triple antibiotic solution, such as "DABS solution" (gentamicin [40 mg], neomycin [250 mg] and polymyxin B sulphate [500 000 units]), to help maintain moisture and attack colonised bacteria within the wound bed. Paediatric feeding tubes are placed over the SISWM to allow delivery of 1-3 mL of the antibiotic solution every 24 hours. Secondary dressings and the bolster are then placed over the SISWM and feeding tube to secure the SISWM to the wound bed. When the bolster is removed postoperatively, if the SISWM has adequately integrated into the wound bed, a skin graft or flap can be placed directly over the wound.

In our experience, the use of this technique has been associated with a notably shortened duration between wound presentation/infection or exposure of tendon or bone and development of beefy-red granulation tissue formation, thereby allowing closure with either a skin graft or flap. This technique promotes expedited bridging between presentation and closure. The following cases demonstrate the application of this technique.

3 | CASE EXAMPLES

3.1 | Patient 1

A 44-year-old female presented with an acute wound resulting from a spider bite to the posterior aspect of the right knee. The patient was initially treated conservatively with oral antibiotics and palliative care. Within a few days, she developed cellulitis, a low-grade fever and extreme pain, and was referred for emergency treatment.

The patient was taken to the operating room. The soft tissue surrounding the bite contained localised necrotizing fasciitis with extensive non-viable soft tissue including epidermis, dermis, subcutaneous tissue, and fascia. After surgical debridement of the soft tissues, SISWM was sized to completely cover the wound bed and make contact with the surrounding healthy skin edges. It was placed on the wound in a dry state and then hydrated with saline. The other components comprising the bolster technique were applied to the patient. One mL of the DABS solution was instilled into the feeding tube every 24 hours for 10 days.

Ten days later, the patient was returned to the operating room. Infection, induration, inflammation, and cellulitis all had resolved. Because there was adequate granulation tissue present, a full-thickness skin graft (FTSG) was indicated. Any unincorporated residual SISWM was removed and the wound was debrided to stimulate active bleeding from the

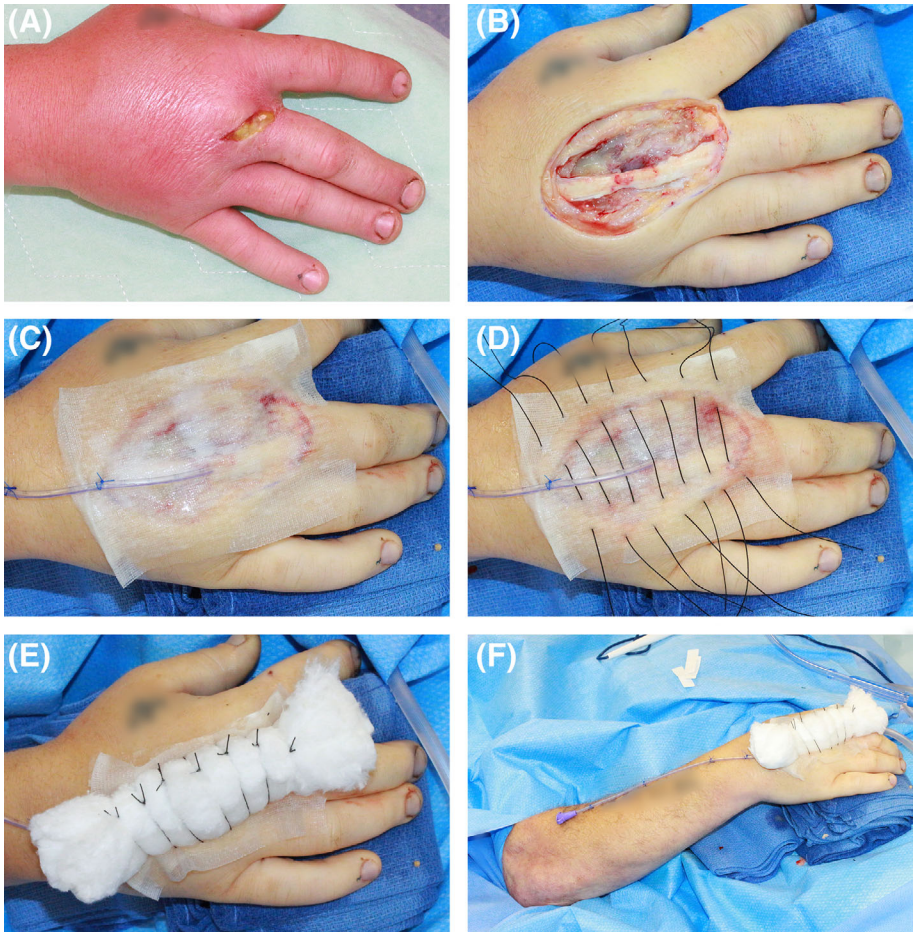

FIGURE 1 A, Presentation of wound, cultures obtained; B, excisional debridement performed; C, SISWM applied to the base of wound, 8FR paediatric feeding tube sutured in place and wound covered with Adaptic coated with mupirocin ointment; D, silk sutures placed; E, cotton moistened with mineral oil and silk sutures to create the bolster dressing; F, complete bolster dressing with patient-accessible paediatric feeding tube

base of the wound. An FTSG was harvested and placed onto the wound. One week later, all dressings were removed; the patient had a 100% take of the FTSG. Five months postoperatively, the patient had no significant complaints and was ambulating freely (Figure 2).

3.2 | Patient 2

A 12-year-old male sustained injures from an all-terrain vehicle (ATV) accident. He presented with a traumatic injury to the right foot that included severe full-thickness third degree burns to the medial aspect of the great toe, the dorsum of the foot, and the lateral calf. The patient presented with complete loss of soft tissue covering the medial aspect of the great toe as well as cortical bone loss of the first metatarsal. Additionally, the patient experienced full-thickness soft tissue loss over the extensor tendons, including the paratenon, all of which necessitated the need for the SISWM bolster technique.

The patient underwent surgical debridement of his wounds, coverage of the exposed bone with fascial flaps, and followed by placement of SISWM and the bolster components described earlier. The patient was placed in a bulky short-leg splint and sent home with instructions to instil 1 mL of the DABS solution into each of the feeding tubes every 24 hours for 10 days.

Ten days later, the patient returned to the operating room for full-thickness skin grafting to both wounds on the foot. Six weeks after the patient's initial injury, he returned to full activities with no significant complaints of pain or discomfort and described no residual functional impairment. His physical examination revealed complete 100% take of both skin grafts (Figure 3).

3.3 | Patient 3

An 80-year-old female on anticoagulants sustained an avulsion injury to her left lower leg caused by her wheelchair. The patient initially received treatment by the local emergency department. Within 24 hours, she developed a large haematoma, which resulted in complete necrosis of the avulsed skin flap. The patient was admitted to the hospital and referred for a plastic surgery consultation.

The patient underwent surgical debridement of the haematoma and all non-viable soft-tissue. SISWM and the bolster technique components were applied to the wound. One week later, the patient underwent a second debridement surgery and SISWM, and the bolster technique components

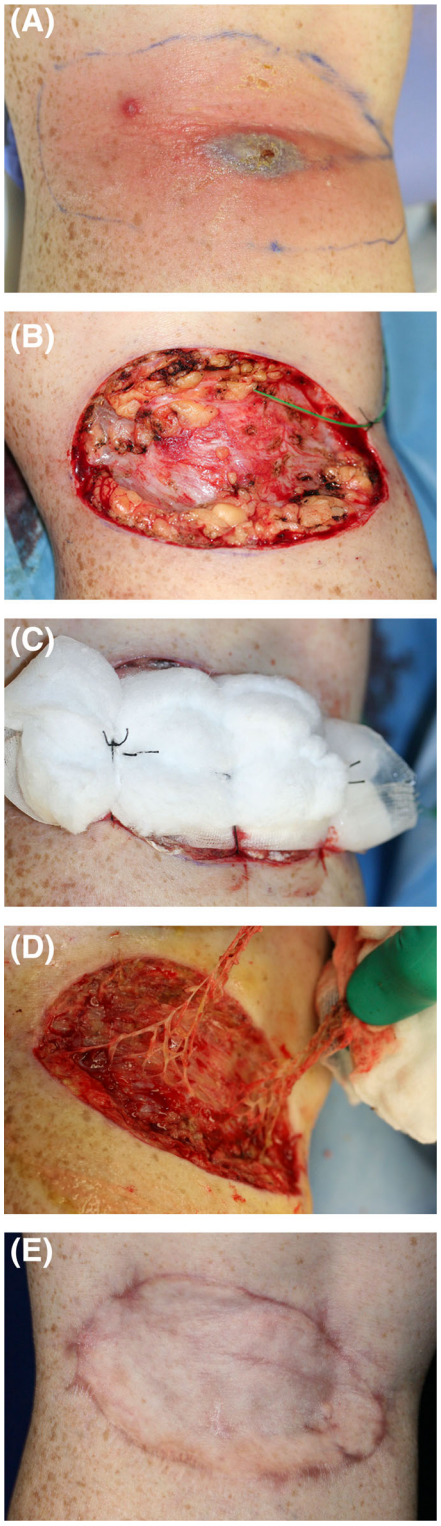

FIGURE 2 A, Spider bite presentation; B, after debridement, paediatric feeding tube placement; C, SISWM, secondary dressing and bolster applied; D, 10 days later after one application of SISWM; E, 3.5 months after initial injury

were re-applied. The wound was instilled with 2 mL of the DABS solution every 24 hours. Two weeks after her initial injury, the patient's wound contained adequate granulation tissue for a split-thickness skin graft (STSG). Six weeks after the initial injury, the patient's skin graft was completely healed (Figure 4).

3.4 | Patient 4

A 41-year-old female was evaluated in the emergency department for a severe, complex avulsion injury to the dorsal left forearm sustained from a dog bite. Her injuries were exacerbated due to a history of rheumatoid arthritis treated with long-term use of non-steroidal anti-inflammatories and steroids causing her skin to be extremely thin and friable. The patient was taken to the operating room for a radical resection of all non-viable soft tissue. Additionally, five extensor tendons and muscles were repaired at the time of operation. SISWM and the bolster technique components were applied to the wound. The patient was discharged to home and instructed to instil 2 mL of the DABS solution every 24 hours.

Twelve days later, the patient returned for wound evaluation and subsequent stage 2 wound reconstruction. Upon evaluation, it was determined that the wound had a healthy amount of granulation tissue present to support skin grafting.

Sharp debridement was performed, and a fasciocutaneous advancement flap was used to cover the base of the wound. By using an advancement flap, the amount of STSG required to cover the wound was decreased, and the flap helped in levelling the skin edges in the preparation for the STSG.

Twenty-one days after the initial injury, the patient returned to the operating room for examination of wound under anaesthesia and removal of staples. There was a 100% take of the skin graft.

Five weeks after the initial injury, the patient's wound was completely healed (Figure 5).

4 | DISCUSSION

An acute wound is an injury to the skin that occurs suddenly because of trauma or surgery. Acute wounds can completely heal in as quickly as 3 weeks for minor wounds, and in as long as 12 weeks for complex traumatic wounds.[11] The management of acute wounds has not changed significantly over the years. The basic principles of wound care need to be followed to achieve optimal function and a favourable aesthetic outcome for the patient.[3] The gold standard treatment plan continues to use a multistep approach best known by the acronym, "TIME." First, nonviable **t**issue must be debrided from the wound. Secondly, **i**nfection and **i**nflammation must be controlled. Next, **m**oisture balance must be optimised. Finally, **e**pithelialization and granulation tissue formation

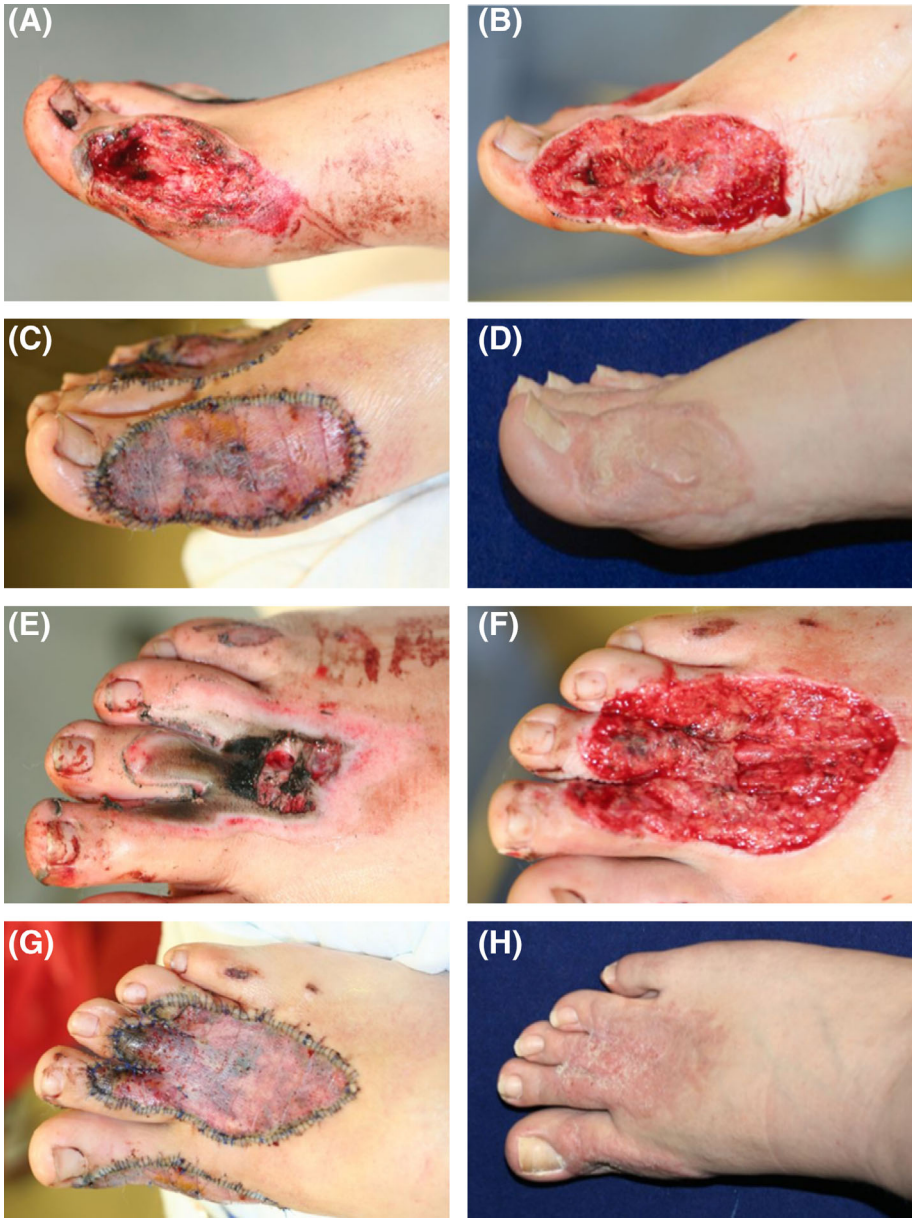

FIGURE 3 A, ATV injury to medial great toe at presentation; B, 10 days later after debridement and one application of SISWM; C, 1 week after FTSG; D, 6 months after initial injury; E, ATV injury to dorsal foot; F, 10 days later after debridement and 1 application of SISWM; G, 1 week after FTSG; H, 6 months after initial injury

should be supported by the application of specific therapies,[2] in this case series, a SISWM and the bolster technique.

By using the TIME framework, a systematic approach for the assessment and management of acute wounds can be followed, and that includes the selection of wound dressings. The aim of any wound dressing is to assist with timely wound healing and subsequent closure.[12] There are an abundance of wound dressing materials available, ranging from gauzes, transparent films, hydrogels, and alginates to collagens including xenografts and biologic or synthetically engineered materials. Each have their own unique features and benefits. Although debatable, there are several characteristics that a wound dressing material should possess to help aid in successful wound healing. Most could agree that management of wound exudate, intimate contact of the wound dressing material with the wound bed, and control/removal of microbes from the wound bed are all ideal characteristics of a wound dressing material.[12] Use of a SISWM and the bolster technique can successfully meet these criteria as demonstrated in this case series.

SISWM is a naturally occurring acellular, collagen-rich matrix derived from the submucosal layer of the pig small intestine. It has mechanical properties and composition similar to human extracellular matrix. SISWM not only acts as a scaffold into which cells can infiltrate and grow into the defect where SISWM is applied, but it also contains a rich assortment of bioactive factors that promote this ingrowth. These factors include cytokines, glycosaminoglycans, proteoglycans, fibronectin, and growth factors

FIGURE 4 A, Avulsion injury to anterior lower leg; B, after debridement; C, 14 days after initial injury and two applications of SISWM; D, 6 weeks after initial injury

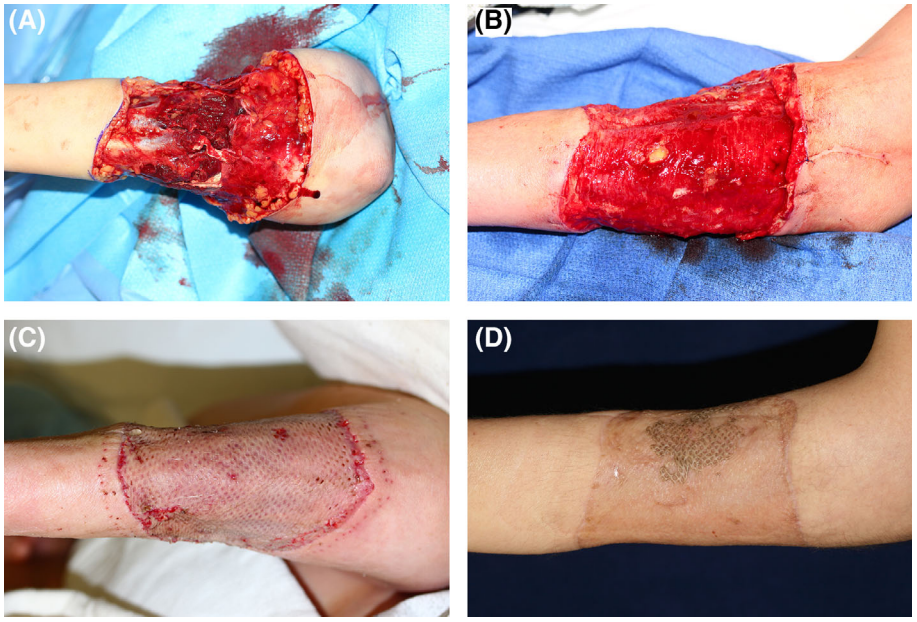

FIGURE 5 A, Dog bite wound, after extensive debridement; B, 12 days after initial injury and one application of SISWM; C, 21 days after initial injury; D, 3 months after initial injury

such as fibroblast growth factors (FGFs),[13] which are important to the wound healing process.[14,15] Over time, SISWM is metabolised by the patient's own collagen turnover mechanism, completely replacing it with the patient's own tissue and cells, resulting in re-epithelization of the wound.[5]

The use of SISWM in wound care has been subject to strong clinical research, including two randomised controlled trials (RCTs) within the past 4 years. These RCTs studied the use of SISWM to treat full-thickness pressure ulcers[16] and diabetic foot ulcers,[17] and all were associated with positive results for the SISWM groups. Although there is robust literature describing the use of SISWM in chronic wounds, there is a paucity of literature describing the use of SISWM in acute traumatic wounds. The positive outcomes presented within this case series were due to the use of SISWM and the bolster technique. Before using this novel technique, these patients would have undergone a fasciocutaneous rotation flap or a free flap. The patients would have incurred significantly longer recovery times with greater morbidity than was experienced with the use of this novel technique. By combining SISWM with the bolster technique, particularly the deliberate and consistent instillation of the DABS solution, we are ensuring that infection and inflammation are controlled, moisture balance is optimised,

and epithelialization and granulation tissue formation are supported.

The use of topical antimicrobial agents in a wound is not a new concept. Topical antibiotics are often used locally at the surgical site as a way to prevent wound infection. For many decades, it has been a common practice to instil antibiotics directly into irrigation solutions as a way to remove debris and foreign material, which often contain bacteria, from a wound.[18] Haines et al[19] reported in 1982 that "surgical wounds with a high risk of infection should be treated with intraoperative topical antibiotics." Fast forward to today, and antimicrobials, such as polyhexamethylene biguanide, silver, and iodine, continue to be used routinely for wounds that are at-risk for infection.[9] DABS solution, used as a postoperative intermittent instillation of a triple antibiotic solution, helps to maintain moisture and attack colonised bacteria within the wound bed, thus encouraging wound healing.

These case reports illustrate that this novel technique might be a helpful tool in the healing of traumatic acute wounds. Although the data are antedoctal, we suggest that using SISWM and the bolster technique for traumatic acute wounds can be a more effective alternative to current traditional means of acute wound care management. More studies are warranted to further substantiate the therapeutic benefits of this novel treatment.

5 | CONCLUSION

Acute wounds with significant tissue loss present a unique treatment challenge to clinicians. The bolster technique, when combined with an SISWM, is a novel method designed to enable the SISWM to impart its wound healing properties to these complex traumatic wounds. This case series presents treating clinicians with a different treatment methodology to assist the patient in achieving a successful outcome.

DISCLOSURE OF INTERESTS

S.C.S. and J.P.H. are employed by Cook Biotech Incorporated. F.J.C. has no financial interest to declare in relation to the content of this manuscript. The article processing charge will be paid for by Cook Biotech Incorporated.

AUTHOR CONTRIBUTIONS

F.J.C., S.C.S., and J.P.H. contributed to the project concept and design, acquisition of data, data interpretation, drafting of manuscript, critical review of manuscript, and final approval of manuscript.

ORCID

Samantha C. Stevenson https://orcid.org/0000-0003-3951-8563

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